# EFFECT OF DIFFERENT TRAINING REGIMES ON ECCENTRIC UTILIZATION RATIO OF TRACK AND FIELD ATHLETES

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**A**

**SYNOPSIS**

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# CHAPTER 1

## INTRODUCTION

Power is a fundamental aspect of sports and plays a crucial role in determining the success of athletes and teams. In the context of sports, power refers to the ability to generate force or apply strength in a quick and explosive manner. It involves a combination of strength, speed, and technique to achieve optimal performance. Here are some key areas where power is highly relevant in sports.

Explosive Movements: Power is essential for explosive movements such as sprinting, jumping, throwing, and striking (Paavolainen et al., 1999). Athletes need to generate a significant amount of force in a short period to excel in these activities. For example, a sprinter's ability to explode off the starting blocks and maintain high speed relies on their power output.

Strength and Power Training: Athletes engage in strength and power training programs to enhance their performance. These workouts focus on developing muscular strength and power through exercises like weightlifting, plyometrics, and resistance training. By improving their power, athletes can generate more force, increase their speed, and enhance their overall performance.

Sports-Specific Skills: Different sports require specific power-related skills. For instance, in basketball, power is necessary for explosive vertical jumps during rebounds and dunks. In tennis, power is crucial for serving with speed and generating powerful groundstrokes. Each sport has unique power requirements that athletes must develop and optimize.

Overcoming Resistance: Power is crucial for overcoming resistance, whether it's an opponent, gravity, or other external forces. Sports like wrestling, rugby, and American football rely on power to overpower opponents, break tackles, or hold ground against opposing forces. Power is a determining factor in winning physical battles within a game.

Agility and Change of Direction: Power is not only about linear speed but also plays a vital role in quick changes of direction and agility. Sports such as soccer, basketball, and tennis require athletes to accelerate, decelerate, change directions rapidly, and perform quick cuts. Power helps athletes generate the force needed to execute these movements effectively.

Explosive strength, also known as power strength, is a component of strength that focuses on the ability to generate force quickly. It is the combination of strength and speed in order to produce rapid, explosive movements. There are several factor influence explosive strength are

Muscle fibre Type: The composition of muscle fibre types can affect explosive strength. Fast-twitch muscle fibres (Type II) have a greater capacity for generating force quickly compared to slow-twitch muscle fibre (Type I). Individuals with a higher proportion of fast-twitch fiber tend to have greater explosive strength potential.

Neural Factors: The ability to recruit and activate muscle fibre efficiently plays a crucial role in explosive strength. Neural factors, such as motor unit recruitment and firing rate, coordination, and synchronization of muscle contractions, can impact the speed and force generation during explosive movements.

Strength Levels: A certain level of baseline strength is necessary to develop explosive strength. Improving absolute strength through resistance training provides a solid foundation for generating greater power during explosive movements.

Biomechanics: Efficient movement patterns and biomechanics contribute to optimal force production. Proper technique and body mechanics allow for effective transfer of force and maximize explosive strength potential.

There are several variables that can be used to measure explosive strength. Here are some commonly used variables

Vertical Jump Height: Vertical jump height is a widely used measure of explosive lower body power. It measures how high an individual can jump from a standing position, reflecting their ability to generate force quickly.

Medicine Ball Throw: The medicine ball throw is a test that measures upper body explosive strength. It involves throwing a weighted medicine ball as far as possible, indicating the ability to generate power through the upper body.

Standing Long Jump: The standing long jump measures horizontal explosive power. It involves jumping forward from a standing position, and the distance jumped is an indicator of explosive leg power.

Rate of Force Development (RFD): RFD measures how quickly an individual can generate force. It is typically assessed by measuring the slope of the force-time curve during a specific movement, such as a rapid isometric contraction or a ballistic movement.

Among these variables vertical jump best measures the explosive strength because of several reasons.

Direct Application to Sports: Vertical jumping ability is highly relevant to many sports and activities that involve explosive movements, such as basketball, volleyball, soccer, and track and field events like high jump. The ability to generate power and explosiveness in a vertical direction translates directly to actions like blocking shots, spiking a volleyball, or reaching for a header in soccer. Therefore, vertical jump performance is a practical indicator of an individual's explosive strength in activities that require vertical power.

Whole-Body Involvement: The vertical jump requires the coordinated activation and force production of multiple muscle groups throughout the body. The lower body muscles, including the quadriceps, hamstrings, glutes, and calves, play a primary role in generating the upward force. However, the core muscles, upper body muscles, and even arm swing contribute to the vertical jump. This comprehensive involvement of multiple muscle groups makes the vertical jump a holistic measure of explosive strength.

Maximal Effort: The vertical jump allows individuals to exert maximal effort and generate the highest possible jump height they are capable of achieving. It requires a rapid and forceful extension of the lower body muscles during the concentric phase to propel the body upward. By striving for maximal jump height, individuals can showcase their explosive strength potential and the power they can generate in a short period.

Easy to Measure: Measuring vertical jump height can be done using simple tools such as a vertical jump testing mat, a vertec device, or even just a wall with a measuring tape. This makes it a practical and widely accessible method of assessing explosive strength. Furthermore, vertical jump tests are straightforward to administer and can be repeated easily for tracking progress over time.

Validated and Reliable: The vertical jump is a well-studied and validated measure of explosive strength. It has been used in scientific research, sports performance testing, and talent identification programs. Numerous studies have shown a correlation between vertical jump performance and athletic performance, making it a reliable and effective measure of explosive strength.

While the vertical jump is a valuable measure of explosive strength, it is important to note that it primarily focuses on vertical power (McLellan et al., 2011). Other tests, such as the standing long jump or medicine ball throws, may provide additional insights into horizontal or upper body explosive strength. Combining multiple tests can offer a more comprehensive assessment of an individual's explosive strength capabilities.

Now there are various form of vertical jumps like Squat jump {SJ}, Counter movement jump {CMJ}, Box jump, Hurdle jump etc. Among them squat jump and counter movement jump are best to measure explosive strength because of several reason some of them are as follow:

Functional Movement: Squat jumps and counter movement jumps mimic movements commonly seen in many sports and activities. They involve a rapid eccentric (lengthening) phase followed by an explosive concentric (shortening) phase, similar to actions like jumping, sprinting, or change of direction. By assessing explosive strength through these movements, it provides a measure of functional power that directly relates to sports performance.

Muscular Activation: Squat jumps and counter movement jumps engage multiple muscle groups, including the lower body muscles (quadriceps, hamstrings, glutes, and calves), core muscles, and even upper body muscles to a certain extent. They require coordinated activation of these muscle groups to generate explosive force. Therefore, these movements provide a comprehensive assessment of overall lower body explosive strength.

Maximal Effort: Squat jumps and counter movement jumps allow individuals to exert maximal effort and generate the highest power output they are capable of producing. The movements involve a rapid transition from the eccentric phase to the concentric phase, allowing for a quick and forceful concentric contraction. This enables individuals to showcase their maximum explosive strength potential.

Relatively Simple Execution: Squat jumps and counter movement jumps are relatively simple movements that do not require complex equipment or technical skills. They can be performed with body weight or additional resistance (such as using a weighted vest or holding dumbbells) to increase the challenge. The simplicity of these movements makes them accessible for a wide range of individuals and allows for easy comparison and tracking of progress over time.

Widely Recognized and Validated: Squat jumps and counter movement jumps have been extensively used and studied in research and sports performance settings. There is a significant body of literature supporting their validity and reliability as measures of explosive strength and power.

Now with the help of SJ and CMJ we are going to find stretch shortening cycle. So first we are going to discuss stretch shortening cycle. The stretch-shortening cycle (SSC) is a neuromuscular phenomenon that involves a rapid transition from an eccentric (lengthening) muscle action to a concentric (shortening) muscle action. It refers to the ability of muscles and tendons to store and release elastic energy during certain movements. During the eccentric phase of the SSC, the muscle is stretched under tension. This stretching causes the muscle and its associated tendons to store potential energy like a stretched spring. The stored energy is then released during the subsequent concentric phase, resulting in a more powerful and explosive contraction.

The SSC is used for various purpose some of them are given below:

Increased Power Output: The utilization of the SSC allows for greater power output compared to purely concentric muscle actions. By taking advantage of the stored elastic energy, athletes can generate more force and power in explosive movements, such as jumping, sprinting, throwing, and change of direction. This enables athletes to achieve higher levels of performance in their respective sports.

Increased Jumping Ability: The SSC plays a significant role in vertical jump performance. By utilizing the stored energy from the eccentric phase, athletes can produce greater force and achieve higher jump heights. This is crucial in sports like basketball, volleyball, and high jump, where vertical jumping ability is essential.

Injury Prevention: The SSC also plays a role in reducing the risk of injury. The elastic properties of muscles and tendons help absorb and dissipate forces during eccentric loading, protecting joints and reducing the likelihood of injury. Training the SSC can enhance the efficiency and effectiveness of these protective mechanisms, improving overall resilience and reducing the risk of certain musculoskeletal injuries.

The eccentric utilization ratio (EUR) is a term used to quantify the efficiency with which an individual utilizes the stretch-shortening cycle (SSC) during a movement. It provides a measure of how effectively the stored elastic energy from the eccentric phase is utilized to enhance the subsequent concentric phase. The eccentric utilization ratio calculated as the ratio between counter movement jump and squat jump. The EUR is calculated by comparing the mechanical work performed during the eccentric phase to the mechanical work performed during the concentric phase of a movement. It is typically expressed as a ratio or percentage. A higher eccentric utilization ratio indicates a greater utilization of the SSC and suggests that a larger proportion of the mechanical work performed during the concentric phase is derived from the stored elastic energy generated during the preceding eccentric phase. This implies that the individual is effectively using the stretch reflex and elastic properties of the muscle-tendon unit to enhance force production and power output. Conversely, a lower eccentric utilization ratio indicates that a smaller portion of the mechanical work performed during the concentric phase is derived from the elastic energy stored during the eccentric phase. This suggests a suboptimal utilization of the SSC and a reduced ability to capitalize on the elastic properties of the muscles and tendons. There are various means and method to develop eccentric utilization ratio. Some of them are given below:

Plyometric Training: Plyometric exercises involve rapid and explosive movements that engage the SSC. Exercises like depth jumps, bounding, box jumps, and medicine ball throws can help train the neuromuscular system to utilize the SSC more efficiently. These exercises enhance the stretch reflex, improve muscle-tendon stiffness, and enhance the rate of force development.

Accentuated Eccentric Training: The training which involve higher eccentric load compared to concentric phase. The main aim of this training is to increase force production during concentric phase(Sheppard et al., 2007).

Complex training: It is a training method that comprises of resistance training exercise prior to performing same exercise that is biomechanically similar. Complex training allow athlete to perform high force at higher intensity compared to traditional weight training(Ebben et al., n.d.).

Ballistic training: The training which focus on concentric contraction rather than eccentric contraction. It enhances the motor unit recruitment, firing frequency of muscle. In this training either object or body will be projected.

So I opted this study to compare and find which training methods [ accentuated eccentric training, ballistic training and complex training.] is best for increasing or enhancing the stretch shortening cycle and improving eccentric utilization ratio.

## Statement of the Problem

The purpose of this study is to determine which training method [Accentuated eccentric training, Ballistic training, Complex training] is better for development of eccentric utilization ratio.

## Objectives of the Study

1. The objectives of this study are to show relationship between cross training and eccentric utilization ratio.
2. The objectives of this study are to show relationship between ballistic training and eccentric utilization ratio.
3. The objectives of this study are to show relationship between accentuated eccentric training and eccentric utilization ratio

## Research Questions

Q. Does the nature of different training regimen affect the eccentric utilization ratio?

Q. Can different training regime work on performance enhancement in the athlete?

## Delimitation

- The study is delimited to male university-level athletes
- The age group of subjects will be 18-25 years.
- The study is delimited to the Following Training regime.

    a. Complex training.

    b. Ballistic training.

c. Accentuated Eccentric.

- The study is delimited to male athletes of sprint, jump and throw event.

## Limitations

- There is no measure to find out whether the subject has shown his full honesty while performing the test.
- The data will be collected in non- competitive situation which might change the result sometimes.

## Hypothesis

**Alternative Hypothesis** – There will be a significant difference between accentuated eccentric training, cross training and ballistic training on eccentric utilization ratio.

## Definition and explanation of the terms

**Eccentric Utilization Ratio:** The eccentric utilization ratio (EUR) is a term used to quantify the efficiency with which an individual utilizes the stretch-shortening cycle (SSC) during a movement. It provides a measure of how effectively the stored elastic energy from the eccentric phase is utilized to enhance the subsequent concentric phase.

**Accentuated Eccentric Training:** The training which involve higher eccentric load compared to concentric phase. The main aim of this training is to increase force production during concentric phase.

**Complex training:** It is a training method that comprises of resistance training exercise prior to performing same exercise that is biomechanically similar. Complex training allow athlete to perform high force at higher intensity compared to traditional weight training.

**Ballistic training:** The training which focus on concentric contraction rather than eccentric contraction. It enhances the motor unit recruitment, firing frequency of muscle. In this training either object or body will be projected.

## Significance of the study

- The significance of this study is helpful for coaches to determine which training exercise is better for the development of eccentric utilisation ratio.
- This study will further help in determining which training regime is better for development of explosive jump.
- This study will further help in determining which training regime is better for development of speed.
- This study will further help in determining which training regime is better for rate of force development.

# Review of Literature

***Kozinc, Ž.; Pleša, J.; Šarabon,[2021]*** The difference between squat jump (SJ) and countermovement jump (CMJ), termed eccentric utilization ratio (EUR), is frequently suggested as an outcome that can be used in athletic training design. Unlike performance in SJ and CMJ, which is associated with sports performance, the association between EUR and sports performance is almost unexplored. This study aimed to investigate whether EUR is associated with performance in approach jump, linear sprint and change of direction (CoD) tasks in volleyball players. Forty-five male volleyball players performed SJ, CMJ, 25 m linear sprint, approach jump and two CoD tasks (505 test and modified T-test). EUR was calculated based on jump height, peak power, peak force and average power. SJ and CMJ variables showed moderate to high correlation with approach jump performance (r = 0.42–0.70), small correlation with modified T-test (r = 0.33–0.40) and small to moderate correlation with sprint time (r = 0.35–0.49). EUR showed only small associations with performance variables (r = 0.31–0.34). In all linear regression models with performance outcomes as dependent variables, the CMJ height was always the only statistically significant predictor. Our results support the recent arguments that the EUR offers limited insight into the neuromuscular capabilities of athletes.

***MCGUIGAN, MICHAEL R; DOYLE, TIMOTHY L.A.; NEWTON, MICHAEL1; EDWARDS, DYLAN J.1; NIMPHIUS, SOPHIA1; NEWTON, ROBERT U [2006]*** The eccentric utilization ratio (EUR), which is the ratio of countermovement jump (CMJ) to static jump (SJ) performance, has been suggested as a useful indicator of power performance in athletes. The purpose of the study was to compare the EUR of athletes from a variety of different sports and during different phases of training. A total of 142 athletes from rugby union, Australian Rules Football, soccer, softball, and field hockey were tested. Subjects performed both CMJ and SJ on a force plate integrated with a position transducer. The EUR was measured as the ratio of CMJ to SJ for jump height and peak power. The rugby union, Australian Rules Football, and hockey athletes were tested during off-season and preseason to provide EUR data during different phases of training. For men, EUR for soccer, Australian Rules Football, and rugby was greater than softball (effect size range, 0.83–0.92). For women, EUR for soccer was greater than field hockey and softball (0.86–1.0). There was a significant difference between the jump height and peak power method for the Australian Rules Football, rugby, and field hockey tests conducted preseason ($p < 0.05$). For field hockey, there was a significant increase in EUR from offseason to preseason. Athletes in sports such as soccer, rugby union, and Australian Rules Football appear to have higher EUR values, which reflects the greater reliance on stretch shortening activities in these sports. It does appear that EUR can be used to track changes in training with the values significantly increasing from off-season to preseason. The EUR provides the practitioner with information about the performance of athletes and appears to be sensitive to changes in the type of training being undertaken.

***Manes, Taylor J. Yakle, Eric G. Morris, Jacob D. Mayhew, Jerry L. Mann, Bryan [2019]*** PURPOSE: To compare two forms of reactive strength index (RSI) between college football linemen and backs. METHODS: Linemen (n = 12) and backs (n = 16) were tested for static jump (SJ) and drop vertical jump (DVJ) on a force plate to determine flight time (Ft), ground contact time (GCT), and peak takeoff force (PTF). Peak landing force (PLF) was determined during DVJ. Each player performed 2 trials of each jump with a 1-min rest between. RSI was calculated as a ratio of DVJ to GCT (RSI-1) and Ft/GCT (RSI-2). A modified elastic utilization ratio (EUR mod) was calculated as DVJ/SJ.RESULTS: Linemen were significantly heavier (127.9 ± 7.8 kg) than backs (92.0 ± 7.8 cm) but the two were not statistically different in age (20.2 ± 1.3 vs 19.8 ± 1.6 yrs, respectively) or height (186.5 ± 6.0 vs 183.6 ± 6.0 cm, respectively). Reliabilities for GCT (ICC = 0.870), SJ Ft (ICC = 0.952), DVJ Ft (ICC = 0.959), DVJ (ICC = 0.958), and SJ (ICC = 0.949) were high. GCT was not significantly different between backs (0.275 ± 0.055 s) and Linemen (0.288 ± 0.039 s). RSI-1 and RSI-2 were greater in backs (1.26 ± 0.37 and 1.95 ± 0.42, respectively) than in linemen (0.77 ± 0.18 and 1.47 ± 0.23, respectively) with large effect sizes (ES = 2.78 and 2.11, respectively). RSI-1 (1.05 ± 0.38) was statically greater than RSI-2 (1.74 ± 0.42), although they were highly correlated (r = 0.95). EUR mod was significantly higher in backs (0.91 ± 0.13) than in linemen (0.75 ± 0.14) with a large ES = 1.69). PLF/kg was not significantly different between linemen (47.2 ± 7.5 N/kg) and backs (49.5 ± 8.3 N/kg) but PTF/kg was significantly greater in backs (40.8 ± 6.4 N/kg) than in linemen (34.7 ± 3.5 N/kg). Discriminant analysis indicated that JH/kg could correctly classify 94% of backs and 100% of linemen to the correct position CONCLUSIONS: Various ratios indicating the ability of players to handle their body weight during explosive movements may be useful in classifying playing position and evaluating training improvement.

***Haff, G; Ruben, R; Molinari, M; Painter, K; Ramsey, M W; Stone, M E; Stone, M H [2010]*** The ability to use the stretch shortening cycle (SSC) is essential for many sporting activities. There are several approaches by which to assess the SSC. These include the eccentric utilization ratio (EUR), the reactive strength calculation (RSC), and the percent pre-stretch augmentation (PPA). These measures are typically quantified for vertical jump displacements and power outputs. The assessment of the SSC activity via jumping activities may yield valuable information of the athletes training status and potential training interventions to improve SSC performance. To determine if EUR, RSC and PPA are related to dynamic and isometric muscle actions. Twenty seven college track athletes (age = 19.6 ± 1.0 y; body mass = 83.0 ± 25.2 kg; height = 176.9 ± 8.8 cm) performed three types of countermovement vertical jumps (CMJ) and static vertical jumps (SJ) on a force plate. Both CMJ and SJ were performed in unloaded and loaded (11 kg and 20 kg) conditions. All jump data were analyzed for vertical displacement, peak force (PF), and rate of force development (RFD). The EUR (CMJ/SJ), RSC (CMJ-SJ), and PPA ((CMJ-SJ)/SJ) × 100) were calculated for jump height, peak power, and peak force Additionally, subjects performed 2 isometric mid-thigh pull with previously established methods. The isometric mid-thigh pulls were analyzed for PF and RFD. Finally, each subject

performed a one repetition maximum back squat test (1-RM) and a maximal ball throw test. There were no significant correlations between the EUR (jump height, PP, PF) for loaded or unloaded jumps and back squat, ball throw, isometric PF, and RFD. All EUR values were above 1, which is indicative of well trained athletes. Significant inverse relationships were found between the PPA calculation for PF during the unloaded condition and squat 1-RM ($r = -0.85$), ball throw distance ($r = -0.74$), and isometric PF ($r = -0.55$). Additionally, during the loaded conditions (11 and 20 kg) the PPA calculation for PF was significantly correlated with the back squat 1-RM (11 kg: $r = -0.89$; 20kg: $r = -0.81$), ball throw distance (11 kg: $r = -0.824$; 20kg: $r = -0.65$), isometric PF (11kg:$r = -0.60$; 20kg: $r = -0.56$), and the isometric RFD (11kg: $r = -0.43$; 20kg:$r = -0.36$). The PPA calculation for peak power during the loaded conditions was significantly correlated with the 1-RM back squat (11kg; $r = -0.89$; 20kg: $r = -0.62$), ball throw (11kg: $r = -0.72$; 20kg: $r = -0.56$), isometric PF (11kg: $r = -0.47$; 20kg:$r = -0.40$), isometric RFD (11kg: $r = -0.43$; 20kg: $r = -0.42$). The isometric RFD can be estimated by the equation: RFD = −58168.7 (PPA for PP 11kg) + 10866.415 or RFD = −142636.9 (PPA for PP 20 kg) + 10340.226. This study suggests that unloaded or loaded PPA has a relationship with an athlete's 1-RM in the back squat, the ball throw distance, and isometric PF generating capacity.
Additionally, under loaded conditions the PPA appears to be related to the isometric RFD. The utilization of CMJ and SJ testing is common place in strength and conditioning and the data calculated from these measures may yield valuable information about performance capacity. The significant relationship between the 1-RM back squat and PPA suggests that strength is an underlying mechanism in the ability to utilize the SSC. Additionally, the PPA assessment may be useful in predicting the isometric RFD.

***Suchomel, Timothy J, Sole, Christopher J, Stone,*** Michael H. [2016]

uchomel, TJ, Sole, CJ, and Stone, MH. Comparison of methods that assess lower-body stretch-shortening cycle utilization. J Strength Cond Res 30(2): 547–554, 2016—The purpose of this study was to compare 4 methods that assess the lower-body stretch-shortening cycle (SSC) utilization of athletes. Eighty-six National Collegiate Athletic Association Division I athletes from 6 different sports performed 2 squat jumps and 2 countermovement jumps on a force platform. Pre-stretch augmentation percentage (PSAP), eccentric utilization ratio (EUR), and reactive strength (RS) for jump height (JH) and peak power (PP) magnitudes, and reactive strength index–modified (RSImod) were calculated for each team. A series of one-way analyses of variance with a

Holm-Bonferroni sequential adjustment were used to compare differences in PSAP, EUR, RS, and RSImod between teams. Statistical differences in RSImod ($p < 0.001$) existed between teams, whereas no statistical differences in PSAP-JH ($p = 0.150$), PSAP-PP ($p = 0.200$), EUR-JH ($p = 0.150$), EUR-PP ($p = 0.200$), RS-JH ($p = 0.031$), or RS-PP ($p = 0.381$) were present. The relationships between PSAP, EUR, and RS measures were all statistically significant and ranged from strong to nearly perfect ($r = 0.569–1.000$), while most of the relationships between PSAP, EUR, and RS measures and RSImod were trivial to small ($r = 0.192–0.282$). Pre-stretch augmentation percentage and EUR, RS, and RSImod values indicate that women's tennis, men's soccer, and men's soccer teams may use the SSC most effectively, respectively. Pre-stretch augmentation percentage, EUR, RS, and RSImod values may show vastly different results when comparing an individual's and a team's ability to use the SSC. Practitioners should consider using RSImod to monitor the SSC utilization of athletes due to its timing component.

***Hellberg, Peter; Hartman, Michael J; Winchester, Jason B [2010]*** The purpose of this research was to examine the influence of external loading on vertical jump and SSC performance in recreationally active college-aged adults. Twenty-four subjects (12 male, 12 female) who routinely participate in recreational sports or exercise volunteered for this study. Vertical jump height was determined using a static jump (SJ) and counter movement jump (CMJ) using a contact-mat under normal and loaded conditions. An external load equal to 5% of the subject's body mass was applied via a weighted vest. Following a standardized warm-up, subjects were allowed one practice jump at each condition. Subjects maintained a hands-on-hip position in order to

concentrate on hip-leg power and minimize jumping technique differences resulting from arm swing. Three trials were given for each condition, with instruction to obtain maximal height on each jump. Peak power was estimated from vertical jumps using the equation developed by Sayers et al. [PP (W) = (60.7) × jump height (cm) + 45.3 × body mass (kg) -2055]. The reliance of SSC was determined using the eccentric utilization ratio (EUR), which is derived from the difference between SJ and CMJ and was determined under both conditions. A repeated measures ANOVA was used to determine group differences and differences between jumps and loading conditions. There were significant differences in jump performance ($p < 0.05$) between males and females as such all results are analyzed by gender. Comparisons of jumps under different loading conditions determined that the application of external load significantly reduced jump height ($p < 0.05$) in SJ and CMJ for both groups, whereas peak power was only significantly reduced ($p < 0.05$) for CMJ in the male group. When subjects were tested for SSC utilization, the external load had a significant effect on EUR power in only the male group (1.37%; $p = 0.02$). Data from this investigation suggests that an external load, such as protective athletic equipment, may have an influence on vertical jump and SSC performance in recreational athletes. In males, an applied external load decreases CMJ power output and influences the ability to maximize the use of SSC. Given that the CMJ is a commonly used tool to assess performance capabilities, practitioners may wish to consider the addition of an external load while testing to more accurately reflect the conditions in which sport performance will occur for their particular event. Further investigation is

needed to determine if the results from this study are consistent when testing highly trained athletes.

***Fidanka Vasileva, Andrijana Misovski, Josko Milenkoski, Georgi Georgiev, Aleksandar Aceski, Angjel Vasilev[2022]*** Vertical jumps are a defying predictor of performance in sports that require explosive action. Objectives of the present study are: 1) to evaluate anthropometric characteristics (height, body mass and BMI), explosive strength (squat jump, countermovement jump and countermovement jump with an arm-swing) and kinematic parameters (the arm swing jump contribution and the eccentric utilization ratio) in female volleyball players; and 2) to compare assessed parameters between youth and junior players. Thirty participants, players that are part of Macedonian Youth (N=15) and Junior (N=15) National Teams, aged 13-18 years, were included in the study. Anthropometric characteristics were measured according to the WorldHealth Organization manual, explosive strength was assessed with the Optojump system, and kinematic parameters were calculated as proposed by Abdel-Rahman (2013). SPSS 23 statistical package was used to perform statistical analysis. Normality of data distribution was tested by K-S test, Skewness and Kurtosis values. Appropriate statistical methods were used to calculate descriptive statistical parameters, and t-test was applied to determine the significance of the difference between youth and junior players. In addition, Cohen's d was applied to calculate the effect size. No statistically significant differences were found between youth and junior players in parameters assessed. Coaches should take in consideration anthropometric and morphological characteristics of the players during the selection process, and work more in a direction of motor abilities development and improvement of

technical skills, especially in pioneer and youth categories, instead of putting the main emphasis on player specialization at early age.

# Chapter 3

## Procedure

In this chapter, the selection of participants, selection of variables, criterion measures, administration of the test, collection of data and statistical technique applied will be described.

Selection Of Participants

Random sampling method for the collection of data and selection of participants will be applied. The age group of the athletes is 18-25 yrs. ±1yr. The athletes are selected from LNIPE.

## Selection Of Variables:

a. Eccentric utilization ratio.
b. Height
c. Take-off force
d. Impact force
e. Maximum concentric power
f. Average Speed during the concentric phase
g. Peak speed
h. Reactive strength calculation (RSC)
i. Percent pre-stretch augmentation (PPA)

## Administration Of Test:

The test will be conducted with the help of a G sensor. First, we will collect pre-data on the G sensor by conducting a counter movement jump and a squat jump. After that, I will provide training to three different groups. One group is assigned complex training, the second group is assigned accentuated eccentric training, and the third group is assigned ballistic training. Testing will be completed at week zero (pre), week 3 (mid), week 6, and week 9 to monitor changes over a 9-week training period program.

## Collection Of Data:

The data will be taken individually of every single participant by making them perform the test. A total of 40 participants will be included.

## Data Analysis:

Two-way repeated measures analysis of variance (ANOVA) (training program × time) were performed to identify significant differences between and within groups. An alpha level of 0.05 was used as the criterion to determine significance. Post hoc tests were used to determine where the differences existed. The effect size was calculated to indicate the magnitude of the difference.

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